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DEVELOPMENT OF IRRADIATED BEEF

II. EFFECTS OF IRRADIATION TEMPERATURE AND DOSE ON THE QUALITY OF ROAST BEEF

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Gary W. Shults

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Irradiated Food Products Group

Radiation Preservation of Food Division

Project: 1T762724AH99

July 1974

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Food Engineering Laboratory

FL-181

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DEVELOPMENT OF IRRADIATED BEEF. II. EFFECTS OF IRRADIATION TEMPERATURE AND DOSE ON THE QUALITY OF ROAST BEEF

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FOREWORD

These experiments were conducted to determine the effects of several irradiation temperatures and doses on the sensory characteristics and preference rating of beef roast. Five portions of the beef carcass and two grades of beef were used to determine these effects of the irradiation parameters.

Results from these experiments have shown the advantages of using lower grades and cuts of beef as the raw materials for irradiation processing and that the low temperature irradiation is essential for producing acceptable irradiated roast beef.

These studies were undertaken as a research project of the Irradiated Food Products Group, Food Engineering Laboratory, under Project IT762724AH99, Radiation Preservation of Foods.

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Introduction

The process of irradiating beef at subzero temperatures has been established as one of the predominate methods for reducing the deleterious effects of ionizing radiations. Brasch and Huber (1948) reported many of the chemical changes and reactions attributed to the ionizing rays could be avoided by the use of low temperatures during irradiation. The authors concluded that improvements in the odor and flavor of the food products could be made by this reduction of the chemical changes during irradiation. Coleby (1961a) found that beef was sensitive to irradiation and the damaging effects increased progressively as the temperature during irradiation increased. Coleby also reported that there was little protection from irradiation when beef was irradiated at +18°C, but there was a rapid increase in protection when irradiated in a range of 0° to -20°C. This protection from the damaging effects of irradiation continued in smaller degrees down to -196°C. Coleby (1961b) reported that test panels preferred beef irradiated at 5 megarads -75°C to beef irradiated at 2 Megarads +18°C and Snyder (1960) found that the off-odor formation in beef steaks irradiated at -196°C was at threshold levels when compared with the non-irradiated controls.

Harlan et al. (1967) and Kauffman et al. (1969) found a linear decrease in the irradiation-flavor intensity of beef steaks irradiated at 3.0. 4.5, and 6.0 megarads in a range of +20°C to -196°C. Wadsworth and Shults (1966) reported that irradiation flavor intensities decreased with the lowering of the irradiation temperatures, but no linear relationships were observed between intensity values and irradiation

temperatures. The authors also found that choice beef roast irradiated at -196°C was preferred to samples irradiated at -50°C and +4°C. Shults and Wierbicki (1974) reported a difference (significant at the 5% level) in preference scores for beef loin samples irradiated at -50°C and -185°C, but no differences were observed between the samples irradiated at -80°, -120°, and -185°C.

Although irradiation at subzero temperatures is encouraging for reducing the adverse effects of irradiation on acceptance, it does not solve all the problems encountered in the irradiation of beef. Grecz et al. (1965) using D_{10} values for spores reported that the lethal effects of gamma rays decreased by 47% in ground beef when irradiated at -196°C, as compared with 0°C. As a consequence, the cans inoculated with 5×10^5 spores of C. botulinum 33A, required 0.9 megarad more irradiation at -196°C than at 0°C to inactivate the spores. In another paper, Grecz et al. (1971) reported that the resistance of C. botulinum 33A spores to irradiation in cooked beef increases with the decrease of the temperature during irradiation in the temperature range from +65° to -196°C. This resistance increase follows equally well a quadratic, exponential, or linear best-fit plot. Therefore, as the temperature during irradiation is decreased, the total dose must be increased to assure sterility of the products.

The objective of this investigation was to determine the effects of irradiation temperature on roast beef prepared from various grades and muscles and the effects of varying irradiation doses on the quality of the beef products. The information obtained from this investigation

will be used for the selection of the most suitable muscles and grades of beef for development of radappertized (irradiation sterilized) roast beef and other beef products.

Materials and Methods

Meat Samples

The beef muscles utilized for these studies were from boneless loin, round, and chuck of U.S. Choice and U.S. Commercial grades of beef.

To investigate the effects of irradiation on the sensory characteristics and preference ratings of various cuts of beef, U.S. Choice and U.S. Commercial loins (Longissimus muscle) and the top round (Semimembranosus muscle) were irradiated at 0°, -80°, and $-185^{\circ}C$.

Three sections of beef round were used to determine any difference in the effects of irradiation on the different muscles. The three sections of the U.S. Choice round were the top, semimembranosus; bottom rounds, biceps femoris and semitendinosus muscles; and the knuckle, consisting of the Rectus femoris, Vastus intermedius, Vastus lateralis, and the Vastus medialis muscle.

The chuck roast used in this study was U.S. Choice boneless, outside, pot roast.

Pre-Irradiation Processing

Samples for all tests were prepared as roast beef items. The raw meat was trimmed of excess fat and formed with a hydraulic press into rolls using fibrous, regenerated cellulose casings, 100 mm in diameter. The samples were cooked in a steam retort ($104^{\circ}C$) to an internal temperature of 70°-$75^{\circ}C$. After enzyme inactivation, the fibrous casings were

removed and the meat was packed in 404 x 309 or 404 x 700 cans. The cans were sealed 16 k Pa of pressure, frozen, and stored until irradiation.

Irradiation Processing

All samples were irradiated in a 1.2 million curie Cobalt^{60} source. The doses stated for the studies are minimum doses. The actual doses received by the beef items were in a range of 100 to 125% of the minimum dose. The temperatures during irradiation were controlled using an automated liquid nitrogen system. The temperatures were controlled within $\pm 10^{o}C$ of the desired temperature during irradiation.

Post-Irradiation Processing

Evaluation

All samples were subjected to taste testing as hot roast beef by trained technological panels of 7 to 8 panelists. The panelist evaluated for the sensory characteristics: discoloration, off-odor, mushiness, friability, irradiation flavor, and off-flavors, other than irradiation flavor. The ratings for the sensory characteristics were made using an intensity scale of 1 to 9, with 1 denoting "none" and 9 being "extreme".

Preference ratings were obtained using both trained technological panels and consumer-type panels consisting of 30 to 36 untrained panelists. Indications of preference were made on a hedonic scale of 1 to 9, with 1 being "dislike extremely" and 9 meaning "like extremely". A rating of 5, "neither like nor dislike", was considered the borderline in determining the acceptability of the product.

Statistical analysis were performed on all the data to determine significant differences between the samples in respect to the sensory

characteristics and the preference ratings. Statistical significance was determined at the five percent level by using an analysis of variance table and multiple range test (Duncan, 1955).

Results and Discussion

U.S. Choice and U.S. Commercial beef loins (Longissimus) and U.S. Choice rop round (Semimembranosus) were irradiated at 4.5-5.6 megarads at irradiation temperatures of 0^{o}, -80^{o}, and $-185^{o}C$. Differences in sensory characteristics and preference ratings were determined by technological panels at 0, 1 month, and 2 months of storage.

Table 1 shows the results of the evaluations on U.S. Choice beef loin. There were no statistical differences in the sensory characteristics and preference ratings between the $-80^{o}C$ and $-185^{o}C$ irradiated samples. The $0^{o}C$ irradiated sample was rated significantly different from the $-80^{o}C$ and $-185^{o}C$ irradiated samples for all the sensory characteristics except the off-flavor intensity and preference. The $-80^{o}C$ sample was rated significantly different from the non-irradiated frozen control in off-odor and irradiation flavor intensities. The non-irradiated frozen control sample was significantly preferred to all the irradiated samples.

Evaluations, by technological panels, of U.S. Commercial loins irradiated at 0^{o}, -80^{o}, and $-185^{o}C$ are listed on Table 2. No significant differences in the sensory characteristics were found between the $-185^{o}C$ irradiated sample and the non-irradiated control; however, the non-irradiated control was significantly preferred to all the irradiated samples. The $-80^{o}C$ irradiated sample was significantly different from the $-185^{o}C$

sample in ratings for irradiation flavor and preference. The beef sample irradiated at 0°C showed more intense irradiation changes in the sensory characteristics and was significantly lower in the preference rating.

Evaluation of the results obtained by the technological panel on U.S. Choice top round beef irradiated at 0°, -80°, and -185°C (Table 3) shows the -185°C irradiated sample being similar to the control except for discoloration intensity. Small, but significant, differences were found between the -80°C sample and non-irradiated control for intensity ratings of discoloration, friability and irradiation flavor. No statistical differences were found between the -80°C and -185°C samples. The 0°C irradiated samples were scored as unacceptable by the panelists and this was probably due to the induced undesirable changes in the sensory characteristics.

The results from the technological panels scores on the three types of materials listed on Tables 1, 2, and 3 indicate the necessity of irradiation at cryogenic temperatures. Irradiation at -80°C yielded acceptable products and only minor improvements in product quality were obtained by reducing the temperature to -185°C.

Technological panel results listed in Table 4 were obtained to compare the differences in U.S. Choice and U.S. Commercial loins and Choice top round of beef when irradiated at -185°C. No statistical differences were found in the intensity ratings of the sensory characteristics for top round irradiated sample when compared to the non-irradiated control, except for irradiation flavor. The U.S. Choice loin irradiated samples had a significantly higher irradiation flavor intensity than the other two irra-

diated samples. Both the U.S. Choice and U.S. Commercial loin samples had significantly higher ratings for discoloration and off-odor intensities. Preference ratings indicate that the non-irradiated control was preferred to all the irradiated samples and the U.S. Choice top round samples preferred to the U.S. Choice loin samples. The conclusion drawn from these evaluations was that U.S. Choice top round of beef yields a product which shows less adverse irradiation effects and, therefore, can be successfully utilized as the raw material for irradiation processing of beef products.

For additional studies on irradiation of different cuts of beef, top round, bottom round, and the knuckle section of U.S. Choice rounds of beef were irradiated at -80°C. The samples were stored for one year at 21°C and evaluated at 0, 1, 3, 6, and 12 months. The results from these tests are shown on Table 5.

The intensity ratings for the sensory characteristics were in the range of 1 (none) to 3 (slight). This indicates that three sections of the beef round were only slightly affected by irradiation processing. Preference ratings show that all irradiated samples were acceptable over one year of storage at 21°C; however, the non-irradiated control was significantly preferred.

U.S. Choice Beef chuck roasts were irradiated at -80°C and -185°C and evaluated by technological and consumer panels. The samples were stored at 21°C and evaluated at 0 and 60 days by technological panels. A consumer panel evaluated the samples after 60 days of storage (Table 6).

Technological panels indicated no differences between the -185°C

sample and non-irradiated control for any of the sensory characteristics. A significant difference in discoloration intensity was found between the -80°C irradiated sample and the non-irradiated control. Both the technological panels and the consumer panel found no statistical difference in preference of the samples. The consumer panel rated the -185°C irradiated sample and the non-irradiated control comparable in preference and found the -80°C irradiated sample less preferred, but the difference was not significant at the 5% level.

The results shown for the irradiation effects on different cuts and grades of beef indicate that the beef rounds and chuck of both grades and the lower graded beef (U.S. Commercial) loins were acceptable for use as irradiated beef items. Additionally, an irradiation temperature of -80°C was sufficient to produce acceptable products. However, as mentioned in the introduction, it has been determined that as the temperature of irradiation is lowered, the dose must be increased to assure 12-D sterility in the product (Grecz et al. 1965, 1971).

To compare the effects of different doses on the beef, U.S. Choice top rounds were irradiated at minimum doses of 3.0, 4.5 and 6.0 megarads at the lowest temperature, -185°C. The results in Table 7 show that as the dose increases, the preference ratings of the samples decrease. The sample irradiated at 3.0 megarads was significantly preferred to the 6.0 megarad samples. The intensity ratings for discoloration, off-odor, and irradiation flavor also increased with the increasing of the dose.

Table 8 gives the results on U.S. Choice top round roast irradiated

at the two 12-D irradiation sterilizing doses: 4.7 Mrad -30°C, and 5.7 Mrads -80°C. Preference data from four tests over a 90-day storage period show that roast beef irradiated at these conditions was in the low acceptance range. However, no statistically significant differences were found between the two irradiated roast beef samples, but the roast beef irradiated with 4.7 megarads at -30°C tended to rate higher in preference than the roast beef irradiated with 5.7 megarads at -80°C.

Results from the studies given in Tables 7 and 8 emphasize the problems encountered by technologists in achieving a product of high acceptance when the microbiological sterility requirements are considered. By lowering the irradiation temperature, a corresponding increase in the irradiation dose must be made to assure sterility. As the data indicate, when the dose increases, the deleterious effects of irradiation increase and a lowering of product quality results. Data in Table 8 show that the sterilizing doses of 4.7 and 5.7 megarads at -30° and -80°, respectively, produce roast beef products of similar quality. The cost of irradiation with a dose of 5.7 megarads at -80°C are greater than irradiation with 4.7 megarads at -30°C. A liquid nitrogen irradiation system would be required for production of beef irradiated at -80°C whereas, at least for freezing the product prior to irradiation, mechanical freezers could be utilized for irradiation at -30°C. Thus, the most favorable balance of produce quality, irradiation cost, and required irradiation sterilizing dose appears to be at about -30 ± 10°C. Consequently, this irradiation temperature is being presently used at the NLABS for developing radappertized beef and other radappertized food products.

To further improve the quality of roast beef and other radappertized beef products (particularly the juiciness and flavor of the finished products), the use of small amounts of salt (sodium chloride) below the threshold for the salty taste and the food-grade condensed phosphates, such as sodium tripolyphosphate and sodium pyrophosphate is most promising. Research results of this investigation will be the subject of the next technical report under the general title "Development of Irradiated Beef".

Summary and Conclusions

A reduction of irradiation temperature to -80°C at 4.5 megarads was sufficient to produce an acceptable irradiated roast beef, when using U.S. Choice beef rounds, chuck, and U.S. Commercial loins as the basic raw materials. U.S. Choice beef loins irradiated at either -80°C or -185°C were more adversely affected by the irradiation treatment, which resulted in lower preference ratings than the other cuts of U.S. Choice beef or the U.S. Commercial beef. Samples made from U.S. Choice beef round were found to be preferred, as an irradiated item, to the samples made from U.S. Choice loin muscle.

A comparison of rating for sensory characteristics and preference of three sections of a U.S. Choice beef round (top, bottom, and knuckle) showed no statistical difference over a one-year storage period, except the ratings for mushiness were significantly higher for the knuckle section.

Irradiating with 6.0 megarads at -185°C resulted in induced changes which lowered the preference rating and increased the intensity scores of the undesirable sensory characteristics for flavor, color, and texture

when compared with the beef samples irradiated with 3.0 and 4.5 megarads at -185°C.

Beef irradiated at two 12-D sterilizing doses (4.7 megarads at -30°C or 5.7 megarads at -80°C) were comparable in quality. Thus, there is no advantage of irradiating beef at -80°C ± 10°C.

The roast beef, prepared by the technology described in this report (no additives) and irradiated with a dose of 4.7-5.6 megarads at -30° ± 10°C received the preference ratings on the threshold of acceptability. As such, it will not be attractive to the consumer.

Improvement of the product irradiated at -30° ± 10°C is visualized by changing the technology prior to irradiation. Additions of small amounts of sodium chloride and condensed phosphates are the most promising. Research in the area is in progress and the results will be given in the next technical report of this series of investigations.

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TABLE 1

Effects of irradiation temperature on the quality of U.S. Choice beef loin (longissimus muscle)

Irradiation Temperature	Storage (days)	Sensory Characteristics						Preference
		Discoloration	Off-Odor	Irrad Flavor	Off Flavor	Mushiness	Friability	
0°C	0	3.87	4.87	5.37	1.25	3.50	3.25	3.00
	30	4.25 1/	2.87 1/	4.50 1/	1.25	3.50 1/	3.62 1/	4.00 1/
	60	3.00	3.25	3.75	1.71	3.25	4.25	4.12
-80°C	0	2.00	3.62	3.62	1.25	2.87	2.62	5.12
	30	2.28	2.25 2/	2.75 2/	1.12	2.00	2.00	5.75 2/
	60	1.75	2.12	2.12	1.71	2.75	3.12	5.88
-185°C	0	3.87	2.75	3.38	1.62	2.38	2.38	5.00
	30	2.38	2.38 2/	3.00 2/	1.38	2.30	2.25	5.75 2/
	60	1.87	2.00	2.50	1.57	2.25	2.50	6.19
Non-irrad Control	0	1.38	1.25	1.12	1.12	1.50	1.75	7.50
	30	1.12	1.12	1.00	1.00	1.50	1.38	7.50
	60	1.25	1.13	1.00	1.29	1.38	1.50	7.31

Dose 4.5 - 5.6 Megarads

8 panelists per test

1/ 0°C samples rated significantly different from the -80°C, -185°C, and non-irradiated control for preference and all sensory characteristics except off-flavor.

2/ Significantly different from the non-irradiated control.

Significance at the 5% level

TABLE 2

Effects of irradiation temperature on the quality of U.S. Commercial beef loin (longissimus muscle)

Irradiation Temperature	Storage (days)	Sensory Characteristics						Preference
		Discoloration	Off-Odor	Irrad Flavor	Off Flavor	Mushiness	Friability	
0°C	0	3.75	3.87	3.87	1.12	4.00	4.50	4.33
	30	4.00 1/	3.23 2/	4.25 1/	1.50	4.37 2/	4.12 3/	3.50 1/
	60	3.83	2.66	4.16	1.17	4.16	4.50	3.83
-80°C	0	2.25	3.00	2.50	1.00	3.38	3.87	5.00
	30	3.12	2.87 3/	2.87 2/	1.62	3.12	3.12 3/	5.33 2/
	60	1.37	1.66	3.00	1.37	3.50	4.66	5.25
-185°C	0	1.75	1.75	1.38	1.00	2.25	2.87	6.50
	30	3.00	2.75	2.12	1.38	2.87	3.38	6.00 3/
	60	2.00	2.00	2.16	1.80	2.83	3.66	5.00
Non-irrad Control	0	2.12	1.25	1.25	1.00	2.62	2.38	7.16
	30	2.12	2.12	1.75	1.25	1.87	1.87	6.66
	60	1.00	1.83	1.17	1.40	2.00	2.33	6.50

Dose: 4.5 - 5.6 Megarads

8 panelists per test

1/ Significantly different from the -80°C, -185°C and non-irradiated control.
2/ Significantly different from the -185°C and non-irradiated control.
3/ Significantly different from the non-irradiated control.

Significance at the 5% level

TABLE 3

Effects of irradiation temperature on the quality of U.S. Choice top round (semimembranosus) of beef

Irradiation Temperature	Storage (days)	Sensory Characteristics: Discoloration	Off-Odor	Irrad Flavor	Off Flavor	Mushiness	Friability	Preference
0°C	0	3.38	3.50	3.87	1.12	2.87	2.38	4.43
	30	4.37 1/	3.38 1/	4.50 1/	1.25	2.50	3.50 3/	3.33 1/
	60	4.00	2.75	2.85	2.40	3.71	4.42	4.75
-80°C	0	1.75	1.38	1.87	1.25	1.38	2.25	6.43
	30	2.87 2/	2.38	2.38 2/	1.00	2.62	2.75 2/	5.16 2/
	60	2.25	1.87	2.00	2.00	2.12	3.12	5.62
-185°C	0	1.87	1.38	1.75	1.12	1.62	1.87	6.43
	30	2.75	1.50	1.25	1.12	1.62	1.62	6.50
	60	2.50	1.75	1.75	2.00	1.87	2.62	5.62
Non-irrad Control	0	1.00	1.12	1.00	1.00	1.00	1.00	7.85
	30	1.25	1.25	1.00	1.12	1.87	1.75	7.33
	60	2.42	1.29	1.29	1.60	1.42	1.57	6.62

Dose: 4.5 - 5.6 Megarads

8 panelists per test

1/ Significantly different from the -80°C, -185°C and non-irradiated control.
2/ Significantly different from the non-irradiated control.
3/ Significantly different from the -185°C and non-irradiated control.

Significance at the 5% level

TABLE 4

Effects of irradiation at -185°C on three cuts of beef

Sample	Storage (days)	Sensory Characteristics: Discoloration	Off-Odor	Irrad Flavor	Off Flavor	Mushiness	Friability	Preference
Choice Loin	0	2.12	2.25	3.50	1.50	2.25	2.12	4.87
	30	1.85 1/	2.37 1/	3.57 3/	1.57	1.85	1.42	5.30
	60	4.80	2.75	4.00	2.38	3.38	2.87	3.50
Commercial Loin	0	2.50	2.25	2.62	1.38	2.75	2.75	5.37
	30	1.85 1/	1.85 1/	2.71 1/	1.42	2.14	2.85	5.30
	60	2.38	2.12	1.75	1.38	2.38	2.25	5.25
Choice Top Round	0	2.12	2.00	2.38	1.25	2.12	1.75	6.25
	30	1.72	1.57	2.00	2.00	2.00	2.71	6.00 4/
	60	1.50	1.50	1.85	1.00	1.38	1.85	6.25
Non-irrad Control Top Round	0	1.25	1.25	1.12	1.50	1.50	1.75	7.00 2/
	30	1.14	1.14	1.00	1.00	1.28	1.75	7.50
	60	1.00	1.00	1.00	1.38	1.87	1.87	6.87

Dose: 4.5 - 5.6 Megarads

8 panelists per test

1/ Significantly different from the non-irradiated control.
2/ Significantly different from all irradiated samples.
3/ Significantly different from the U.S. Commercial loin and U.S. Choice round samples.
4/ Significantly different from the U.S. Choice loin sample.

Significance at the 5% level

TABLE 5

Effects of irradiation on the quality of three sections of the U.S. Choice round of beef

Sample	Storage (months)	Sensory Characteristics: Discoloration	Off-Odor	Irrad Flavor	Off Flavor	Mushiness	Preference
Top Round	0	1.50	2.50	2.50	2.56	1.33	5.50
	3	2.12 1/	1.75	1.87	2.75 1/	2.50 1/	6.01
	6	1.71	1.85	1.71	1.85	2.14	6.42
	12	2.00	2.14	2.85	1.28	2.43	5.43
Bottom Round	0	1.50	1.66	1.66	2.16	1.33	6.66
	3	1.62	1.62	1.75	2.25	2.00 2/	6.04
	6	1.42	1.57	1.71	1.83	1.28	6.85
	12	2.07	2.14	2.57	1.71	2.14	6.57
Knuckle of the Round	0	1.16	2.66	1.83	2.33	1.66	6.66
	3	1.75	1.75	2.12	2.12	2.62	6.20
	6	1.57	1.85	1.71	1.83	2.00	6.50
	12	1.71	2.43	2.85	1.28	2.71	5.85
Non-irrad Control	0	1.50	1.33	1.00	1.83	1.16	7.86
	3	1.50	1.12 3/	1.12 3/	1.62	1.87	7.04 3/
	6	1.23	1.00	1.00	1.28	1.57	7.42
	12	1.00	1.00	1.00	1.14	1.00	7.43

Dose: 4.5 - 5.6 Megarads

8 panelists per test

1/ Significantly different from the non-irradiated control.
2/ Significantly different from the Knuckle section.
3/ Significantly different from all irradiated samples.

Significance at the 5% level

TABLE 6

Effect of irradiation temperatures on the quality of U.S. Choice chuck roast

Irradiation Temperature	Storage (days)	Discoloration	Off-Odor	Irrad Flavor	Off Flavor	Mushiness	Friability	Preference	
								Tech	Consumer
-80°C	0	2.82 1/	1.75	2.37	1.75	2.00	2.37	5.88	----
	60	2.50 1/	2.00	2.00	1.62	1.37	1.87	6.12	5.40
-185°C	0	2.31	2.00	2.50	2.25	1.37	1.50	5.75	----
	60	1.75	1.37	2.00	1.50	1.12	1.62	6.75	6.00
Non-irrad Control	0	2.00	1.82	1.50	2.25	1.37	1.12	6.00	----
	60	1.12	1.25	1.62	1.37	1.12	1.50	7.38	6.10

Dose: 4.5 - 5.6 Mrad

N = 8 per test, technological panels

N = 36 per test, consumer panel

1/ Significantly different from the non-irradiated control.

Significance at the 5% level

TABLE 7

Effects of different irradiation doses on the quality of U.S. Choice beef roast irradiated at -185°C

Irradiation Dose (mia)	Discolor-ation	Off-Odor	Irrad Flavor	Mushi-ness	Preference
0 Mrad	1.18 1/	1.00 1/	1.77 1/	1.17	7.64 1/
3.0 Mrad	1.86	2.05	2.62	2.05	6.40 2/
4.5 Mrad	1.90	2.20	3.18	2.36	6.18
6.0 Mrad	2.05	2.41	3.36	2.36	5.54

N = 23

1/ Significantly different from other samples.

2/ Significantly different from 6.0 Mrad sample.

Significance at the 5% level

TABLE 8

Effects of the 12-D sterilizing doses at -30°C and -80°C on the quality of U.S. Choice beef roast

Sample	Storage (days)	Sensory Characteristics						Preference
		Discoloration	Off-Odor	Irradiation Flavor	Off-Flavor	Mushiness	Friability	
4.7 Mrad -30°C	0	2.14	1.42	2.14	2.00	2.14	3.28	5.71
	30	2.71	2.28	2.71	1.71	1.42	2.28 1/	5.71
	60	2.28	2.57	2.57	2.00	2.85	3.28	5.14
	90	3.34	3.85	3.14	2.42	1.28	3.42	4.50
5.7 Mrad -80°C	0	1.71	1.87	2.28	1.42	1.87	3.00	5.57
	30	2.42	2.85	3.42	2.28	2.85	2.85	5.00
	60	2.00	2.14	2.14	2.00	2.00	2.57	5.00
	90	2.42	2.57	3.14	2.42	1.28	2.42	4.85
Non-irradiated control	0	1.42	1.28	1.14	1.28	1.00	1.50	7.28
	30	1.71	1.71	1.14 2/	1.85	1.00	1.85	7.28
	60	1.27	1.00	1.00	1.25	1.25	1.69	7.12 2/
	90	1.85	1.28	1.28	1.71	1.00	1.28	6.28

N = 7-8 panelists per test

1/ Significantly different from the non-irradiated control.
2/ Significantly different from all the irradiated samples.

Significance at the 5% level

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)* A reduction of irradiation temperature to -80°C at 4.5 Megarads was sufficient to produce an acceptable irradiated beef roast, when using choice graded beef rounds, chuck and commercial graded loins on the basic raw materials. Choice beef loins irradiated at either -80°C or -185°C were more adversely affected by the irradiation treatment which resulted in lower preference ratings. Samples made from Choice graded beef round were found to be preferred, as an irradiated item, to the samples made from loin muscle.

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A comparison of rating for sensory characteristics and preference of three sections of a beef round (top, bottom, and knuckle) showed no statistical difference over a one year storage period, except the ratings for mushiness were significantly higher for the knuckle section.

Irradiating at 6.0 Megarads at -185°C resulted in induced changes which lowered the preference rating and increased the intensity scores of the sensory characteristics. This irradiated beef was found significantly different from beef irradiated at 3.0 Megarads at -185°C.

Beef irradiated at the 12-D sterilizing doses (4.7 Megarads at -30°C or 5.7 Megarads at -80°C) yielded products with high intensity scores for the sensory characteristics and relatively low preference ratings. Beef irradiated at the 12-D doses is of lower quality than beef irradiated at lower temperatures.